WASHINGTON
SCIENCE TRENDS

HIGHLIGHTS

SPECIAL REPORT

* Battlefield Illumination
* Image Intensification
* Near Infrared Programs
* Far Infrared Programs

Volume VII, No. 15 December 26, 1961

* NIGHT VISION RESEARCH AND DEVELOPMENT

The U. S. Army Corps of Engineers is engaged in an extensive program of "in-house" and contract basic and applied research and development of equipment and systems for night vision. Major fields of technology include Battlefield Illumination, Low Light Level Image Intensification, Near Infrared and Far Infrared. The following summary, from official sources, lists current efforts and outlines current research problems for which solutions are being sought.

ø Battlefield Illumination: This refers to the use of active visible light systems on, over, or near the battlefield at night to provide the soldier with light levels sufficient to substantially enhance his mobility and combat effectiveness. The predominant advantage of this type of system is that the individual soldier does not need special equipment or viewers. The illumination is provided by searchlights which are directed over or at the areas to be illuminated. Battlefield illumination also includes the use of active visible light in such applications as low level miner's type lights which can be used to accomplish tasks such as missile preparation. This low level light cannot be detected visually except at short ranges. Still another phase of battlefield illumination is the use of visible light for the marking of night parachute drop zones or aircraft landing areas.

Items under research and development are:

□ 30 inch General Purpose Searchlight: This mobile system consists of a carbon arc searchlight with its controls on one trailer and a 20 kilowatt direct current generator on a second trailer. It has 350 million peak beam candlepower, has a range of about 10,000 meters, and can be filtered for use as a near infrared light source.

□ Headmounted Low Level Light: This very lightweight visible light may be worn on the head or on the helmet. It provides low level illumination immediately in front of the wearer sufficient for most night tasks and yet not great enough to be visually detectable at appreciable distances.

□ Light Kit, Marking, Landing and Drop Zone: This kit consists of eight lights, an inverter, and a roll of field wire. Each of the lights may be battery operated individually, or all may be powered by vehicle or a 110 volt generator. Each light can be independently flashed and filtered to various colors. The lights are used for the demarcation of landing and drop zones.

□ Light, Glide Angle Indicator: This battery or vehicle powered light provides glide angle information to pilots by means of a three colored beam directed along the proper glide path.

(Continued)

* NIGHT VISION R & D (Continued)

□ Light Sources: This work includes high pressure xenon lamps with multiple electrodes, vortex stabilized arcs, non-self-consuming anodes featuring fluid transpiration, and initial flashing light studies.

ø Low Light Level Image Intensification: This is defined as the use of natural night skylight, starlight, or moonlight which is reflected from military targets and terrain, and which is intensified many thousand of times in a passive viewer to provide an instantaneous visible image for the observer. The primary advantages of this system are its passive nature, its ability to image moving targets, and the potential light weights and sizes of this type equipment. Low light level image intensifier systems may be used for night fire control, observation, driving, and similar purposes.

Items under research and development are:

□ Small Starlight Scope: This passive imaging weaponsight will be used on handheld weapons. In somewhat different forms it will be used as a handheld binocular and as a night driving device for armored vehicles and general purpose vehicles.

□ Night Observation Device, Image Intensifier: This passive tripod mounted viewer will have a total weight of about 35 pounds. It is to be used as a long range viewer for commanders and surveillance personnel. It may be used as a weaponsight for long range crew served infantry weapons.

□ Night Observation Device for Armored Vehicles: This will be a periscopic passive night observation device for use in armored fighting vehicles.

□ Three Stage Cascade Image Intensifier Tubes: Magnetic focused tubes are under development to replace present electrostatic focused tubes. These tubes have demonstrated a light gain of 25,000 and gains of 100,000 are expected.

□ Fiber Optics Image Intensifier Tubes: Fiber optics have been developed to the extent that adequate resolution and plate sizes are available. Incorporation of fiber optics into single stage tubes will permit the use of three inexpensive tubes instead of one expensive three stage tube.

□ Direct View Storage Image Tube: This tube will permit the observation of stationary objects at very long ranges by taking, in effect, a time exposure with a low light level image intensifier.

□ Low Light Level Image Orthicon Tubes: Image orthicons have been developed with an electrostatic image intensifier front end. A magnetic focus intensifier image orthicon is under development as are image orthicons and in a miniaturized form. These tubes will be used in low light level image intensification systems requiring remote viewing.

□ High Voltage Power Supplies: Very small 16,000 volt power supplies have been developed. These battery operated power supplies are self contained within the viewer.

□ Other: Work is in progress to improve photoemissive surface performance, to achieve better phosphors, to enhance contrast rendition, and many other supporting research fields.

ø Near Infrared Equipments and Systems: These employ an active light source which is filtered to pass only near infrared radiations, and a viewer which converts the infrared radiations reflected from the target and terrain into an instantaneous visible image. Near infrared systems have the advantage that they are not dependent upon the ambient night illumination and that, of the imaging night vision systems, they can provide the greatest viewing ranges excepting, of course, high intensity and readily detectable visible light systems.

* NIGHT VISION R & D (Continued)

Items now in production or type classified are:

□ Infrared Weaponsight: This lightweight weaponsight is replacing the Sniperscope. It mounts on the M-14 rifle and M-60 machine gun, and consists of an infrared viewer using a 6914 image converter tube, an infrared filtered tungsten light source, and a rechargeable nickel cadmium battery which provides power for the light.

□ Image Metascope: This is a small image forming viewer to be used by the front line soldier for detection of enemy infrared sources, or when employed with its own small infrared light for short range observation. It is powered by a hand cranked generator. An even smaller transistorized image metascope has been developed. Both use the 6929 image converter tube.

Items under research and development are:

□ Infrared-Visible Tank Kit: This kit is designed to fit the M48 tank and with the exception of the tank commanders periscope will also fit the M60 tank. It consists of the Xenon Short Arch Searchlight T-1, the XM-32 gunners infrared-visible periscope, the XM-33 tank commanders infrared periscope, and the XM-18 handheld infrared binocular. The searchlight can be rapidly switched from visible to infrared light. The gunners periscope has a wide angle visible viewing channel, a high magnification visible viewing channel, and a high magnification infrared viewing channel. The commanders infrared periscope has a wide angle infrared viewing, and the XM-18 binocular provides an open hatch infrared viewing capability.

□ Infrared Close Order Binocular: This headmounted infrared binocular will have great depth of field, will be lightweight, and will have two companion headmounted infrared lights. This binocular is intended to be used for combat support operations such as first aid, construction, and missile preparation.

□ Unit Commander's Observation Telescope: This viewer will utilize a three stage magnetic focus cascade image converter tube and a low wattage, lightweight infrared light source. It will be used for long range observation by commanders and surveillance personnel, particularly at ranges beyond the capabilities of low light level image intensifiers.

□ Infrared Driving Binocular, T-6A: This is a helmet mounted, lightweight, night driving binocular used in conjunction with infrared filtered vehicle headlamps. This binocular permits night driving at road speeds of about 35 miles per hour without the use of visible light.

□ Three Stage Cascade Infrared Image Converter Tubes: Development of three stage infrared tubes parallels the development of three stage tubes for low light level image intensifiers since the two differ only in the spectral sensitivity of the photoemissive surfaces employed. Magnetic focused infrared tubes are under development including one which has a gating grid. This tube will be used in a very long range viewing system in conjunction with a pulsed infrared light source.

□ Other: Supporting research for most elements of near infrared and low light level image intensifier systems are identical. The description of this mutually supporting research was presented above.

ø "Far Infrared Technology": This is defined as the application of techniques using the natural (thermal) radiation emitted from military targets and terrain features due to their temperatures and surface properties (emissivities). Characteristic features of this technique, as applied to a passive surveillance of the battlefield and as compared with low light level image intensification which is based on observation of radiation reflected from objects, are its independence of the illumination of the object by any artificial sources or natural sources (such as moonlight or starlight);

* NIGHT VISION R & D (Continued)

its ability to detect objects of higher temperature, as most military objects are, thus permitting rapid reconnaissance; and its comparatively larger freedom from the effects of adverse atmospheric conditions. The radiation emitted from those objects of interest to the night vision program of the Corps of Engineers cover a wavelength band with a maximum intensity at about 10 micron. For portable and vehicular mounted devices the wavelength band of primary interest is from 2 to 14 microns where there are wavelength bands in which the radiations are little affected by the presence of water vapor and carbon dioxide in the atmosphere. For vehicular mounted devices an area of additional interest is the region beyond 1000 microns where the radiations are less affected by extreme atmospheric conditions such as fog.

NIGHT VISION RESEARCH AND DEVELOPMENT PROBLEMS

The Army is seeking "early and daring" solutions to the following problems in the area of night vision research and development. Requests for additional information, or proposed solutions, should cite problem number and should be addressed to:

Director, U. S. Army Research and Development Laboratories
Corps of Engineers,
Ft. Belvoir, Virginia

- ENG - 39 -- Develop photondetectors with a response in the 8 to 14 micron wavelength region requiring only moderate cooling possibly using dry ice as the coolant. (Present photon detectors sensitive in the 8 to 14 micron wavelength region require cooling down to temperatures lower than that of liquid nitrogen. New concepts in photon detection should be developed leading to dectors operating at higher temperature without significant loss in detectivity.)

- ENG - 40 -- Develop optical materials transmitting in the 8 to 14 micron region to be used as material for optical elements and windows, preference is to be given to glass-like materials. (Far Infrared devices operating in the 8 to 14 micron wavelength region use at present reflecting optics when large apertures of the receiving optics are required. Replacement of these optics by glass-like transmitting optics is desirable from the standpoint of performance and cost. Such optics will require more than one transmitting material for the design of achromatic optical systems. Also infrared transmitting glasses which can be used in fiber optical systems are needed.)

- ENG - 41 -- Develop efficient cooling devices usable for the operation of detecting elements over long periods of time. (Present cooling devices use liquified gases, mostly in an open cycle process imposing the severe logistic problem of providing extremely dry gases. Closed cycle gaseous or thermoelectric miniature refrigerators should be developed.)

- ENG - 43 -- Design a highly efficient, very bright, large light source for use in battlefield illumination searchlight. (Present light sources for battlefield illumination searchlights have peak brightnesses on the order of 1200 candles per square millimeter and have low lumen output versus electrical power input efficiencies. Greatly improved light sources would permit both the attainment of a higher level of illumination on the battlefield and a reduction in the number of searchlights required. There is a need for a highly efficient light source which has a brightness of 10,000 candles per square millimeter over an area of approximately 75 square millimeters.)

(Continued)

* NIGHT VISION R & D PROBLEMS (Continued)

- ENG - 44 -- Develop an efficient photoemissive surface sensitive to radiations throughout the 0.3 to 4 micron band for use in image intensifier devices. (The two photoemissive surfaces most commonly used in present image intensifier tubes are the multialkali (S-20) and the cesium-silver-oxide (S-1) surfaces. The S-20 surface is used in low light level image intensification systems and the S-1 is employed in near infrared viewers. Since the spectral range of night sky illumination is from about 0.3 microns to 4 microns, the photoemissive surface for a low light level image intensifier should be responsive to this total illumination for maximum efficiency. The present S-20 surface is sensitive only from approximately 0.3 to 0.85 microns. In addition a photoemissive surface sensitive throughout the 0.3 to 4 micron range would make possible a dual capability night vision viewer which could be used without modification for both passive, low light level viewing, and for very long range, near infrared observation.)

- ENG - 45 -- Develop new high resolution, simple electron optics for use in image intensifier tubes. (Present image intensifier tubes use electrostatic focusing. Tubes are under development which use permanent magnets for focusing purposes. The electrostatic focused tubes have poor edge resolution, a problem that is expected to be corrected by magnetic focusing techniques. However, the magnet will add weight to the system and does not permit desired reductions in size. Present electrostatic focus, three stage, cascaded image tubes have a center resolution of approximately 17 line pairs per millimeter with edge resolutions on the order of 2 line pairs. The length per stage varies from 2 to 3 inches in present small electrostatic tubes to an expected 1.5 inches per stage in future magnetic tubes. New electron optics are required which will be compact, simple, inexpensive and will provide good resolution. The goal for the length per stage is 1/4 inch.)

- ENG - 46 -- Develop higher resolution, efficient phosphors for use in image intensifier tubes. (The settled phosphors of current image tubes have electro-visual efficiencies of 40-50 lumens per watt with resolutions of about 50 line pairs per millimeter. High resolution phosphors are essential for cascaded, multistage image intensifiers in order to achieve adequate resolution along the tube axis in the output of the final stage. A new phosphor or a new technique of phosphor placement is needed which will have electro visual efficiencies of 50 to 100 lumens per watt with resolutions of 75 to 100 line pairs per millimeter.)

- ENG - 47 -- Develop microminiature image intensifier tubes for use in ultra lightweight, passive night vision devices. (Present image intensifier tubes, those which are under development, and supporting research projects indicate that very high performance low light level image intensification equipment and systems can be developed within the present state of the art. Brightness gains approaching 100,000 appear to be possible, with tubes which have gains of more than 25,000 having already been built. However, passive night vision devices for many purposes, and in particular for the individual soldier, must be small, lightweight, inexpensive, and yet retain high performance. There is a need for image tubes having an effective surface diameter on the order of 2 inches, and an overall length of 1/2 inch which can provide light gains of 20,000 to 100,000 with resolutions of 30-50 line pairs per millimeter.

- ENG - 142 -- Develop efficient temperature resistant infrared filters for use in xenon searchlights. (Present infrared filters used in close proximity to high intensity xenon discharge lamps can not be produced with both high infrared efficiency and thermal resistance as well. Conventional infrared filters, capable of withstanding temperatures of only 100°C., have infrared efficiencies as high as 10%. The presently available thermal resistant types used with xenon searchlights have infrared efficiencies of only 1.0 or 2.0%.)

* NIGHT VISION R & D PROBLEMS (Continued)

- ENG - 48 -- Design lightweight, inexpensive, optical objective lenses for image intensifier systems. (Passive low light level image intensifiers are designed to work with extremely low light levels, as little as 10^{-6} foot candles scene illumination. Both for the present and in the future it is essential that long range viewing systems have large, high quality objective lenses to provide a substantial optical light gathering capability. Long range near infrared viewers also require large objective lenses. These 5 to 10 inch diameter lenses are very expensive, often costing thousands of dollars, and weigh 15 to 40 pounds, a major portion of the overall viewer weight. There is a need for lightweight, inexpensive objective lenses with diameters on the order of 5 to 10 inches which have high transmission efficiencies for broad spectral ranges.)

- ENG - 49 -- Design simple, compact and inexpensive eye lenses for image intensification systems. (Eye pieces presently used in image intensifier equipments are moderately expensive, are too large for some applications, are limited to fields of view of 40 to 50 degrees, often give a tunnel vision effect, and have a limited exit pupil. Future night vision equipments must be further miniaturized, particularly those items intended for the individual soldier. Many present viewers do not have an adequately wide field of view. There is a need for extremely compact, simple, lightweight, and inexpensive eye lenses, both erecting and non-erecting, which can cover fields of view of 70 to 80 degrees, 10 to 20 power, and with a wide exit pupil on the order of 10 millimeters.)

- ENG - 141 -- Develop an automatic device to protect image intensifier devices from sudden unexpected high intensity flashes of light. (All image intensifier devices in use or under development make use of photoemissive surfaces and/or phosphor screens which are damaged by excessive amounts of energy. Intense flashes of light cause permanent damage to both the photoemissive surfaces and phosphor screens when current densities are allowed to rise beyond a critical value or exist for more than a few milliseconds. The problem of protection is made more difficult by the inability of sensing circuits to differentiate between a normal current existing over a large area and the same current restricted to a small area.)

- ENG - 143 -- Develop a passive ranging technique for use under conditions of darkness, that is able to determine the range of objects seen against an heterogeneous background. (The capability of proposed methods to determine the range of objects under the conditions of darkness is restricted to ranging against point sources viewed against a fairly homogeneous background. For ground-to-ground ranging, the target, usually extended in area, is viewed against an heterogeneous background containing a wide variety of objects of radiance similar to the target radiance. Investigations should be made leading to a ranging system having the described capability.)

GROUP SUBSCRIPTIONS AVAILABLE

Special rates apply when you order Washington Science Trends in quantities of 5 or more; 10 or more and 15 or more within the United States. For information on these special rates -- which permit prompt circulation and retention of each weekly report -- write Circulation Dept., Washington Science Trends, National Press Bldg., Wash. 4, D.C. or call EXecutive 3-0031. (Area Code 202)